DAM SAFETY ASSURANCE PROGRAM
EVALUATION REPORT AND
ENVIRONMENTAL IMPACT STATEMENT

APPENDIX C
ENGINEERING APPENDIX

DOVER DAM, OH
TUSCARAWAS RIVER

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PART 2 – SPECIFIC DISCUSSIONS AND DATA

1 General

Dover Dam is situated on the Tuscarawas River approximately 3.5 miles upstream of Dover, OH, 5 miles upstream of New Philadelphia, OH and 62.5 miles upstream of its confluence with the Muskingum River. State Route 800 passes over the right (north) abutment. There are three structures located upstream of Dover; Bolivar Dam, Leesville Dam, and Atwood Dam. These structures are assumed to operate as designed for purposes of this report. Also the levees associated with Dover Dam, both residential and industrial, are not covered under this report.

Dover Dam is a concrete gravity structure consisting of 14 non-overflow monoliths and 9 spillway monoliths. The design top elevation of the non-overflow sections is 931 with the actual low point on the concrete curb of 931.34. However, the transition monolith on the left (South) abutment, monolith 23, has a low point of 928.5 to allow for the relocation of a railroad which has since been abandoned. This area has been backfilled to an approximate elevation of 934.

The spillway is uncontrolled and has a crest elevation of 916. The outlet works consist of 18 gated sluices in sets of six at differing invert elevations. The right set of sluices are 5’ x 10’ with an invert elevation of 862. The center and left sets of sluices are 7’ x 7’ with invert elevations of 872 and 867, respectively. The spillway monoliths are 75.25 feet wide at the base and the stilling basin extends 124.75 feet from the toe of the dam. The founding elevation of the spillway monoliths varies across the width of the dam with a minimum founding elevation of 830.

The stilling basin consists of three distinct sections as well. These are separated by dividing walls which extend approximately two-thirds of the length of the stilling basin. The sides of the stilling basin are also lined with concrete gravity training walls which have a top elevation of 885.

The non-overflow sections are 17 feet wide at the top with an 8.5 feet wide slab cantilevered to the downstream and supported by concrete arches and columns making the top surface of the dam 25.5 feet wide. The foundation widths and elevations vary.

The operating house is located on monolith 5 of the right non-overflow section and an entrance house is located on monolith 18 of the left non-overflow section. Both of these structures allow access to the operating gallery which runs the full distance through the dam at elevation 882.25 for the left portion and 886.25 for the center and right portions. The foundation drains are located in this operating gallery.

2 References

The primary reference for this report is EC 1110-2-6061 which actually expired on 30 April 2006. However, since the document has not been resubmitted as an ER it is still being used for the production of this report. Other documents referenced for this report may be found in the individual Tabs.

3 Recommended Plan Development

3.1 **Parapet Wall**

A parapet wall is required to avoid overtopping of the non-overflow sections since the stability of these monoliths rely on the earthen embankment downstream remaining intact. The top elevation of the wall was set at 940.0. This elevation is discussed in more detail in Tab I – Hydrology & Hydraulics. I-Walls on both banks and a gate closure across Route 800 are required to tie in to high ground. The I-Wall on the left bank includes fill to ramp over the wall for trail access. This ramp is sloped to meet the requirements of the Americans with Disabilities Act (ADA). The design of the wall is discussed in more detail in Tab IV – Structural.

3.2 **Spillway Anchors**

Stability analysis showed that the only monoliths that would not meet current criteria for all load cases considered were the spillway monoliths. The failure mode for these monoliths is deep seated sliding. Based on the analysis for this report the spillway requires three rows of anchors, one each per monolith, angled at 45 degrees in the upstream direction. These anchors are designed as 59-strand, 7-wire, anchors to be locked off at a prestress of 70% of the ultimate tensile strength. The analysis of the monoliths and design of these anchors are discussed in more detail in both Tab II – Geotechnical and Tab IV – Structural.

3.3 **Stilling Basin Anchors**

Analysis of the dam showed that the stilling basin does not meet criteria for all load cases. The primary failure mode for the stilling basin is floatation. Prestressed bar anchors are utilized to add vertical force to the stilling basin and bring it up to current criteria. Bar anchors were chosen over strand anchors to allow for installation in the wet and better distribute the load. The analysis of the stilling basin and design of these anchors are discussed in more detail in both Tab II – Geotechnical and Tab IV – Structural.

3.4 **Stone Slope Protection**

Increased spillway flows from a PMF event are likely to cause erosion downstream of the stilling basin with the existing project conditions. To protect project park lands and SR 800, bank protection will be necessary. The feasibility-level design option is for use of stone slope protection (SSP). The feasibility-level design would require replacement of existing SSP with larger stone and extended up the bank to a higher elevation. The exact extent, size and technique of bank protection will be verified during the design phase through physical modeling and environmental impact assessments. This is discussed in more detail in Tab – 1 Hydrology & Hydraulics and Tab II - Geotechnical.

3.5 **Erosion Cut-Off Wall**

In addition to erosion on the banks, it is likely the bed rock downstream of the stilling basin would be eroded during extreme spillway flows. The recommended plan includes a concrete cut-off wall to prevent this erosion from undermining the dam. This wall consists of overlapping

six feet diameter drilled shafts which will extend below the estimated scour depth. Every other one of these shafts is assumed to have minimal reinforcing to ensure the integrity of the wall. The shafts are assumed to be constructed in the wet with tremie concrete techniques. Physical hydraulic modeling during the design phase will verify the need and extent of wall required. This is discussed in more detail in Tab IV – Structural.

3.6 **Resident Engineer's Office and Lab**

A Resident Engineer's (RE) Office and Laboratory is proposed to be constructed approximately one half mile north of Dover Dam off of Ohio Route 800 near the current Dover Project and Muskingum Area Offices. See Figure No. 1 for the proposed location of the RE Office. The building will be constructed on U. S. Government property. Design of the building will be similar to the Bluestone Dam RE Office with slab on grade foundation, block and frame structure, parking, and will be enclosed in a perimeter fence. It is intended during the design phase to incorporate features that will allow use of the structure for operation purposes once it is no longer needed during construction of the Dover DSA and other Muskingum Area projects.

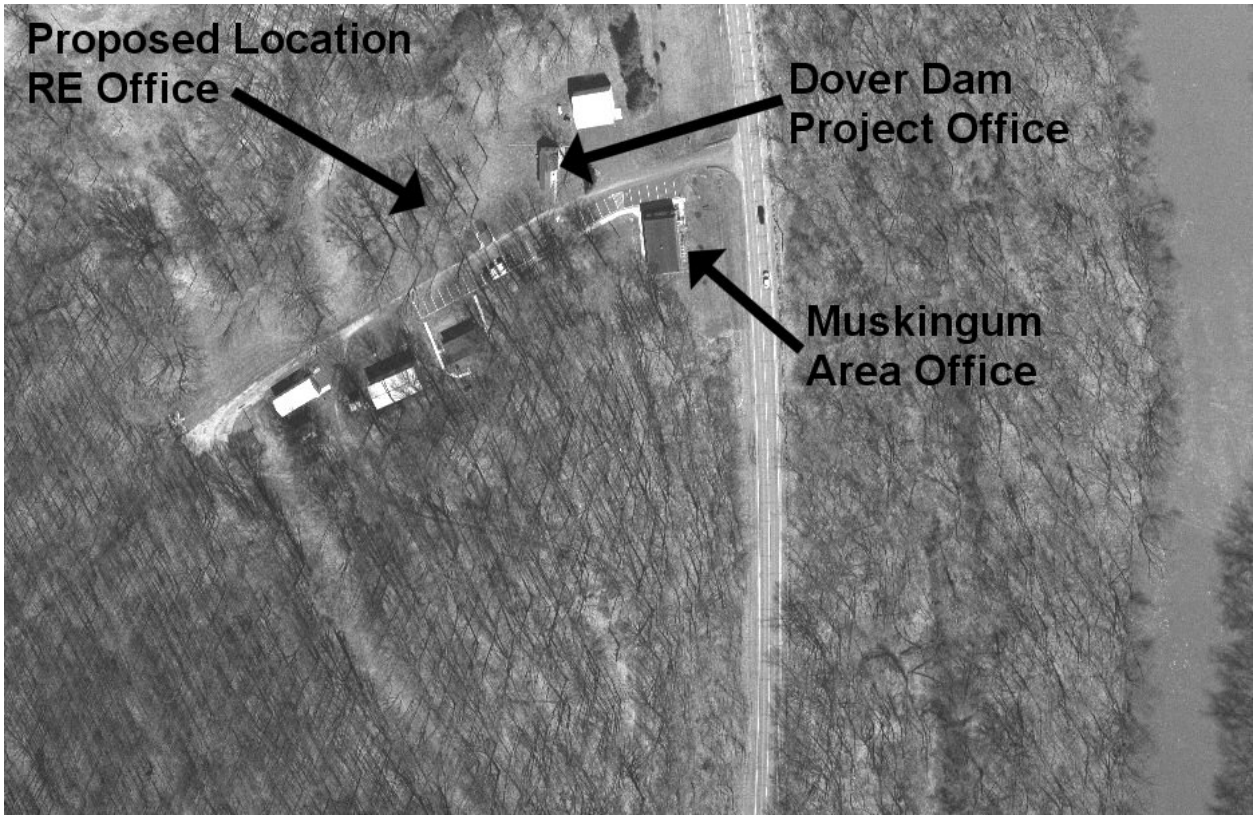

Figure 1. Site for Resident Engineer Office

3.7 **Contractor's Work Limits**

Refer to Exhibit No. 1 in the main report which shows the Contractor's Work Limits (CWL) in the vicinity of the dam for construction of the Dover DSA project. Access to the Dover Dam right abutment will be via Ohio Route 800 and existing project roads. The CWL will include a portion of Route 800 for construction of a gate closure and drainage features. The CWL will

include the upstream project road for installation of the parapet wall and anchors, and downstream recreation area access road for replacement of stone slope protection and staging. The CWL will also include a portion of the river upstream and downstream of the dam for floating plant access to anchor the spillway and dam. Access to the downstream recreation facility will be closed to the general public for use as a contractor staging area during construction.

Construction access to the left abutment is proposed by acquiring an easement for approximately 7,300 ft of abandoned railroad bed downstream of Dover Dam to Township Highway 317 as shown in Figure 2. The abandoned railroad will be widened to 30 ft. for use as the primary access to the left abutment for construction and staging. An existing aggregate road upstream of the left dam abutment will be made available for contractor use for passenger vehicles only. This road is approximately 10,000 ft. long and traverses U.S. and privately owned lands. It is subject to occasional flooding by the Dover Dam pool and is bordered by wetland areas. The contractor will be prohibited from widening the road or impacting the wetland areas by restricting the CWL to 15 ft. in width for the length of the road. Work on the left abutment of the dam will involve construction of a parapet wall on the dam, an I-wall from the dam crossing the abandoned railroad and tying into high ground, and replacement of downstream stone slope protection. Downstream of the left abutment will also be the primary staging area and dam access location for installation of anchors.

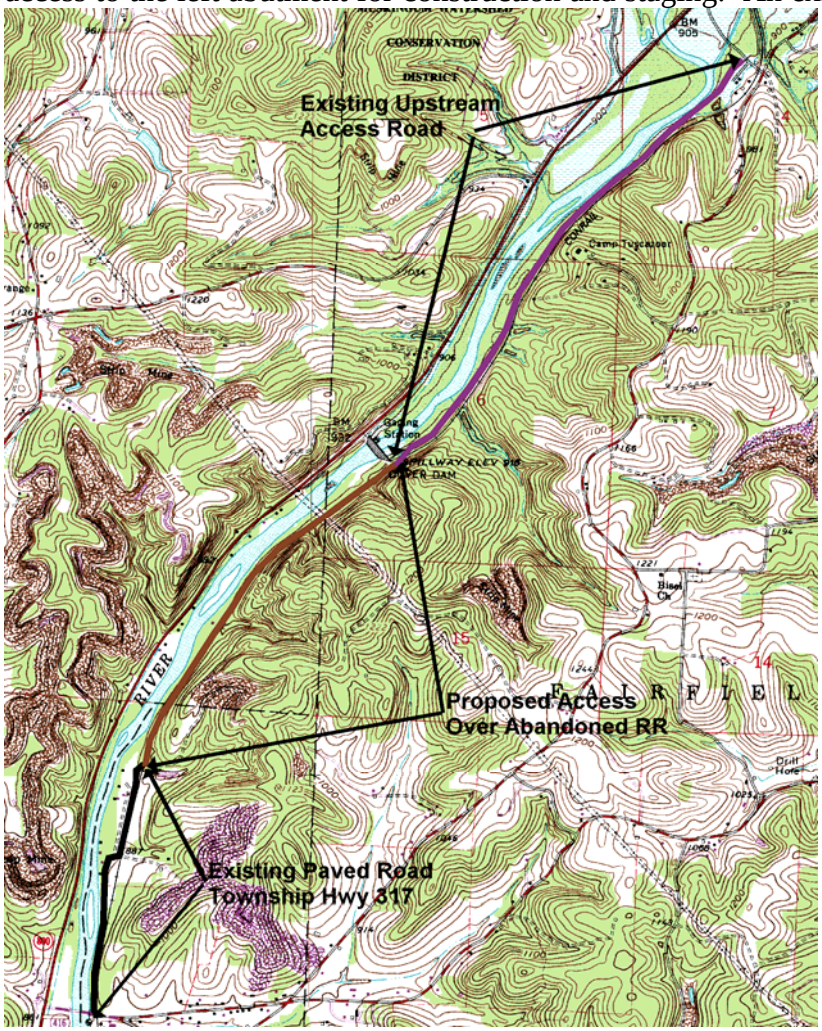

Figure 2. Access to Left Abutment

4 Baseline Cost Estimate

The baseline cost estimate has been prepared for each of the considered project features for the recommended plan, which includes raising and anchoring the dam and downstream erosion control features. The PDT developed a project implementation schedule for the preferred

alternative which has been used in developing the fully funded cost estimates. The baseline cost estimate at PL 1 October 2006 is $94 million. The fully funded cost estimate including inflation over multiple years of implementation is $103 million.

5 Engineering Studies and Investigations

5.1 **Surveying and Mapping**

Dover Dam Aerial Photography and Topographic Mapping

On March 18, 2001 aerial photography was taken for map compilation of Dover Dam. The photography was taken at a scale of 1:8000, a flying height of approximately 4000 feet above mean terrain. The photographic coverage included approximately 6600 acres extending 10,000 feet downstream to 14,000 feet upstream of Dover Dam.

From this photography topographic mapping was compiled using ASPRS Class I accuracy standards for a horizontal scale of one inch equals one hundred feet and a two foot contour interval. This topographic mapping was performed using Ohio North State Plane zone on the North American Datum of 1927. The vertical datum was the National Geodetic Vertical Datum of 1929. The topographic mapping of Dover Dam included approximately 206 acres extending 2500 feet downstream to 2000 feet upstream of Dover Dam.

Ohio Statewide Imagery Program

In the spring of 2006 imagery and LIDAR data was collected for the northern portion of Ohio. Products from this statewide program will include orthophotography at a one foot pixel resolution and a digital elevation model with two meter spacing. These products are being performed to National Map Accuracy Standards for one inch equals two hundred feet horizontal scale and two foot contour interval. These products are schedule for completion on December 31, 2006 and will be available through the Ohio Office of Information Technology.

5.2 **Hydrology and Hydraulics**

Hydrologic and hydraulic studies were conducted to develop inflow hydrographs for use in analyzing the performance of Dover Dam for existing conditions and for an array of alternatives for correction of the hydrologic deficiencies of the project. These studies included the development of the probable maximum rainfall, routing and combining of hydrographs to the dam, and determining outflows adjustments to simulate operation of the dam for downstream flood control during the beginning of the design event. Flood profiles and inundation maps were generated for use in determining the downstream hazards in terms of population at risk and economic damages. Details of these studies are presented in Tab I – Hydrology and Hydraulics.

5.3 **Geotechnical**

Seismic Ground Motion Study.

In 1999, FMSM Engineers, Inc. was contracted to develop preliminary seismic ground motion parameters for all projects within the Muskingum River basin. The study was designed to provide a basis for future, more detailed ground motion studies as required, and to determine parameters for use in limited seismic safety reviews. The Dover Dam project is located in Unified Building Code Seismic Zone 1, a zone of minimal seismic activity. The study results are summarized in Tab II, the Geotechnical Appendix of this DSA Report.

Drilling and Testing.

Two subsurface investigative programs have been completed. The first program, completed in 1983, consisted of drilling fifteen (15) NX borings (3 vertical and 12 angled) from inside the operations gallery. In the second program, initiated in 2004, fourteen (14) borings were drilled along the abutments. The overburden was sampled in each boring using the Standard Penetration Test method (2-inch split spoon), and 4-inch rock core samples were obtained using conventional coring techniques. Rock samples from the 2004 program were tested in 2005 to obtain shear strengths and bearing capacities, for use in structural analyses performed for this evaluation report. See Tab II - Geotechnical for a detailed discussion on the geotechnical studies and geological conditions at the dam site.

5.4 **Materials**

As part of the concrete materials and stone slope protection investigation for Dover Dam DSA, a survey of nearby ready-mix concrete plants was performed to determine their sources of fine and coarse aggregates, cementitious materials, admixtures and mixing water. Four ready mix companies were located within a reasonable hauling distance from the project. The materials used by these companies will be tested and/or investigated during the DDR Phase of this project. A review of various lists of potential sources has been performed, including COE TM 6-370; mineral producer surveys for Ohio prepared by the state geologic survey and ODNR mineral producer surveys; and the Huntington District aggregate and stone slope protection source files. Several potential sources of aggregate and stone were determined to be within an economically feasible distance of the project. A list of aggregate sources tested and acceptance limits that were developed for the Piedmont DSA project (another dam within the Muskingum Basin) was also reviewed. Two of these sources will be re-tested for the DDR phase of this project. More information is included in Tab V – Materials.

5.5 **Structural**

Structural analysis of the dam was limited to three representative monoliths. Monolith 5 was used to represent the right non-overflow portion of the dam, Monolith 7 was used to represent the spillway section of the dam, and Monolith 17 was used to represent the left non-overflow portion of the dam. Limited structural design was performed for the other appurtenant features since these could be estimated with a good level of confidence from similar projects and/or typical details. The structural analysis is discussed in more detail in Tab IV – Structural.

5.6 **Relocation Studies**

Construction of the Dover Dam DSA Project will affect utilities and highway facilities located within the Project limits. Discussion on the relocation and/or alteration of utilities and/or facilities shall be included in the Dover Dam DSA Design Documentation Report (DDR). This report will address all relocation issues including the following: Attorney's Reports of compensability; exhibits showing the company's facilities to be relocated, altered, and/or abandoned; the determination of substitute facilities; cost estimates; views of the owner; and proposed method of settlement. Relocations contracts will be executed with the appropriate facility owners based on the approved DDR. These relocations contracts will follow the standard formats provided in ER1180-1-1, Appendix A.

Utilities affected by the proposed project include power and telephone. Preliminary attorney's opinions indicate that American Electric Power (AEP) holds a compensable interest in the land occupied by its power facilities and Verizon holds a compensable interest in the land occupied by its telephone facilities affected by the proposed project. To qualify for just compensation for their affected facilities under EFARS, Appendix Q, the utility must be vested with a compensable interest in the land occupied by their facilities that must be relocated, altered, and/or abandoned to accommodate the project.

Ohio State Route 800 is also affected by the proposed project. A preliminary attorney's report indicates the Ohio Department of Transportation (ODOT) holds a compensable interest in the said highway. See Tab III – Relocation for a more detailed discussion of Relocation requirements.

5.7 **Hazardous, Toxic, and Radioactive Waste (HTRW) Investigations**

A Phase I HTRW Investigation was conducted on the Contractor's Work Limits (CWL) of the proposed Dover Dam DSA Project. As a result of findings in the Phase I Investigation, possible Phase II(a) HTRW Investigations were recommended for the following areas of the CWL: Dredge material decant area located on both the left and right descending streambank upstream from Dover Dam, river sediments located in any construction areas (due to oil spill in 1995), and the area around previous USACE boring No. C-04-05. Additional sampling is also recommended for the railroad ties located along the proposed access road and any excavated soil near the pit toilets located in the day use area downstream from Dover Dam. Phase II (a) HTRW Investigation activities are not deemed necessary on any of these areas until post-DPR project implementation activities are ready to begin. At that time the need for Phase II (a) HTRW Investigations on these properties will be re-evaluated. See Appendix G of the Evaluation Report for more information concerning the investigation conducted on this area.

5.8 **Environmental Design**

Significant adverse impact to most resources was successfully avoided through thorough consideration of resource impacts throughout the study process. Impacts that were considered unavoidable include, minor temporary noise and air emissions, minor aquatic and terrestrial impacts. Best management practices were used to minimize adverse effects.

The proposed project lies within the range of the clubshell mussel (Pleurobema clava), a Federally-listed endangered species. Substrate and flow conditions immediately downstream of the existing stilling basin are favorable for the mussel species. Therefore, at least in theory, portions of this project including streambank protection and construction of the spillway cut-off wall have potential to impact the clubshell mussel. The known distribution of the clubshell mussel and its habits make the presence of individuals proximal to the project unlikely. Nevertheless, the Corps is aware of expanding mussel populations within the system. As detailed construction methods and impact assessments are undertaken, the Corps will survey the impact zone for the presence of the clubshell. Surveys will be scoped and conducted in partnership with the USFWS pursuant to Section 7 of the Endangered Species Act based on detailed project information. Alternatives to the proposed SSP are available and may be employed as design and impact information is developed.

Currently, the feasibility-level details of the project can not support a robust biological assessment or effective feedback from the USFWS. The project details are suitable to demonstrate that impacts are unlikely and that the designer has feasible options available in the event that a biological assessment requires adjustments to the plan during detailed design. The Corps will undertake such analysis as a first action following a USACE decision to pursue detailed design one of the project alternatives.

Adverse impacts could occur to the aesthetic/cultural resource value of the Dover Dam with the implementation of either alternative. However, during project design the Corps will consider measures to preserve the aesthetic/cultural value of the dam, to the extent possible, while meeting dam safety requirements.

A detailed discussion of impacts of project alternatives and proposed mitigation is included in Section 2.5 of the Evaluation Report/Environmental Impact Statement.

6 Construction

6.1 **Construction Schedule**

Construction of the RE Office is scheduled to commence in May 2008 with a 9 month duration. This is to be complete prior to starting construction on the remedial measures for the dam. The primary construction contract for the recommended plan is scheduled to commence in March 2010 with a 32 month duration. This puts the scheduled completion of the project in October 2012.

6.2 **Construction Methods**

The RE Office will utilize standard small (one-story) commercial building construction methods. The building will consist of a shallow concrete foundation with a slab on grade floor and stick built and/or masonry walls.

All of the construction methods to be utilized are typical to large civil works projects. Exact methods will generally be left up to the construction contractor but the anticipated methods for the main features are discussed briefly below.

The parapet walls will likely be precast reinforced concrete panels to be cast off site and delivered to the project. Erection will require a large crane to lift the panels and hold them in place while they are anchored to the dam. Removal of some of the existing concrete may be required by various mechanical means prior to installation of the panels.

The I-walls foundations consist of both driven sheet piling and drilled piles. The cap will be cast-in-place reinforced concrete. Sheet piling will be driven using either vibratory or impact devices mounted to a crane or excavator. The holes for the drilled piles will be bored using a typical drill rig and the piles will be placed in the holes and grouted solid.

A platform will likely be constructed at the downstream face of the dam to accommodate a drill rig for placement of the strand anchors in the spillway monoliths. Depending on the final size and arrangement of the anchors and required tolerances, specialized directional drilling may be required. The anchors will be grouted in the holes and stressed with a hydraulic jacking system and the anchor heads will be encased in concrete. Various performance test measures will be required throughout the anchoring process.

The stilling basin anchors will be installed in the wet. Holes will be drilled using either a barge mounted rig or from the aforementioned platform. The threaded anchors will be grouted in the holes and prestressed using hydraulic jacks and locked off with nuts. Much of the stressing operation can be done from above water but divers may still be needed for certain portions.

The stone slope protection will be delivered on trucks and placed using typical earth moving equipment. Prior to placement the topsoil and/or existing stone will be stripped and a filter fabric will be placed.

The erosion cut-off wall will require a larger drill rig that that used for the anchors or other drilled piles. A steel casing will be spun into the top portion of rock then the hole will be excavated to the proper depth. The holes will then be filled with concrete using tremie concrete methods. Alternating holes will be placed with those requiring reinforcing to be placed last to avoid cutting the reinforcing while drilling adjacent holes.

Other appurtenant features, such as utility work and site drainage, will not require any specialized equipment or construction techniques.

6.3 **Construction Season**

Based on the climate of the area, the anticipated construction season should last from April through November. Much of the construction is weather dependent, both temperature and precipitation, so the exact dates of major construction activities will vary from year to year. Also, certain restrictions will be in place for activities that take place in or near the water depending on pool and outflow conditions.

7 Operation and Maintenance

The recommended plan does not affect the day to day operation and maintenance of the dam. The only additional requirements of project personnel are the knowledge of the Route 800 swing gate operation and periodic test closures of this gate. Operations personnel will also be consulted during the design and layout of the Resident Engineer's Office such that it can be designed to accommodate future use for operations activities after construction closeout.

Tab I – Hydrology and Hydraulics

Tab II – Geotechnical

Tab III – Relocations

Tab IV – Structural

Tab V – Materials

Tab VI – Quality